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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/588,833	09/02/2008	Charles M. Lieber	H0498.70217US02	4453

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EXAMINER	
WOLVERTON, DAREN A	
ART UNIT	PAPER NUMBER
2813	

MAIL DATE	DELIVERY MODE
06/12/2009	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/588,833	LIEBER ET AL.	
	Examiner	Art Unit	
	DAREN WOLVERTON	2813	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *03 August 2007*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *126-145* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *126-145* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *09 August 2006* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *See Continuation Sheet*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

Continuation of Attachment(s) 3). Information Disclosure Statement(s) (PTO/SB/08), Paper No(s)/Mail Date :06/04/2009, 09/19/2008, 02/14/2008, and 08/03/2007.

DETAILED ACTION

Information Disclosure Statement

The information disclosure statement filed 08/03/2007 fails to comply with 37 CFR 1.98(a)(2), which requires a legible copy of each cited foreign patent document; each non-patent literature publication or that portion which caused it to be listed; and all other information or that portion which caused it to be listed. Namely it fails to include the following non-patent literature publications:

FRIEDMAN, "High speed integrated nanowire circuits," Nature, 434: 1085 (2005).

"IBM creates highest performing nanotubes transistors", IBM News, 2002.

The omitted references have not been considered.

The information disclosure statement filed 06/04/2009 fails to comply with 37 CFR 1.98(a)(2), which requires a legible copy of each cited foreign patent document; each non-patent literature publication or that portion which caused it to be listed; and all other information or that portion which caused it to be listed. Namely it fails to include the following non-patent literature publications:

Office Action from Serial No. 11/543,337 dated March 18, 2008

The omitted references have not been considered.

Drawings

The drawings are objected to as failing to comply with 37 CFR 1.84(p)(5) because they include the following reference character(s) not mentioned in the

description: 33 and 34. Corrected drawing sheets in compliance with 37 CFR 1.121(d), or amendment to the specification to add the reference character(s) in the description in compliance with 37 CFR 1.121(b) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Claim Objections

Claims 140 and 143 are objected to because of the following informalities: these claims use the term "promoting a method comprising an act of" which is confusing, though based on the specification it is clear that the applicant desires that the diffusion by intentionally caused rather than the incidental result of bringing a metal into contact with silicon. Appropriate correction is required.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

Claims 126-127, 129-132, 135-137, 140-143, and 145 are rejected under 35 U.S.C. 102(e) as being anticipated by Hareland et al. (US 6,897,098) (*Hareland* hereinafter).

Regarding claim 126 and 137, *Hareland*, in FIG. 1 and FIG. 2, discloses a method comprising: providing (FIG. 1) a semiconductor nanoscale wire 106 (specifically a silicon nanowire, see column 4, lines 14-17); patterning a mask 108 (called a sacrificial gate stack by Hareland) on the nanoscale wire 106 to define at least a first portion 114 (called a second region by *Hareland*) not covered by the mask 108 and a second portion covered by the mask; exposing the first portion but not the second portion to a bulk metal (column 6, lines 23-34); and diffusing at least a portion of the bulk metal into the first portion of the nanoscale wire (column 6, lines 23-34).

Regarding claim 127, *Hareland* further discloses, in column 4, lines 14-40, that the semiconductor nanoscale wire comprises silicon.

Regarding claims 129-131, *Hareland* further discloses, in column 6, lines 28-29, that the metal silicide comprises nickel silicide (which is formed from the diffusion of nickel, a transition metal).

Regarding claim 132, *Hareland* further discloses, in column 4, lines 41-58, that the first portion of the nanoscale wire has a smallest dimension less than 200 nm.

Regarding claim 135, *Hareland* further discloses, in FIG. 2, that the mask 108 is a second nanoscale wire (note that length 130 of the first nanoscale will is disclosed as about 100nm in column 4, lines 43-44).

Regarding claim 136, *Hareland* further discloses, in FIG. 2, that the second nanoscale wire 108 comprises a core 108 (called a sacrificial gate stack by Hareland) and a shell 110 (called a first spacer by Harland). Note that the broadest reasonable definition of shell including "an outside covering", for which the spacers qualify as can be seen in FIG. 2.

Regarding claim 140-143 and 145, *Hareland*, in column 6, lines 20-34, discloses a method of diffusing at least a portion of a bulk metal (specifically nickel) into at least a portion 114 of a semiconductor nanoscale wire 106 (specifically a silicon nanowire, see column 3, lines 14-40) to form a metal silicide (specifically nickel silicide), the bulk metal and the semiconductor nanoscale wire being adjacent (this is part of the conventional silicidation method), wherein the semiconductor nanoscale wire 106 comprises at least one portion having a smallest dimension of less than about 500 nm (column 4, lines 41-58).

Claims 138 is rejected under 35 U.S.C. 102(e) as being anticipated by *Hareland* as evidenced by Deng et al. ("Silicidation process using NiSi and its device application") (*Deng* hereinafter).

Regarding claim 138, *Hareland* discloses all of the limitations of claims 126 and but does not disclose that the first region has a resistivity of less than about 60 microOhm cm.

Deng, in FIG. 1, discloses that the resistivity of nickel silicide is less than 60 microOhm cm and therefore it is inherent that the nickel silicide in the invention of *Hareland* has a resistivity of less than 60 microOhm cm.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 128 and 144 are rejected under 35 U.S.C. 103(a) as being unpatentable over *Hareland* in view of *Deng*.

Regarding claims 128 and 144, *Hareland* discloses all of the limitations of claims 127 and 143 but does not disclose that the metal (nickel) and the silicon have a stoichiometric ratio after diffusing.

Deng, in the last paragraph on page 8048, discloses that NiSi, which has a one to one stoichiometric ratio, is formed in the conventional silicidation process.

Therefore, in view of *Deng*, it would have been obvious to one of ordinary skill in the art at the time of the invention to create a 1:1 stoichiometric ratio of nickel to silicide thereby forming NiSi.

One of ordinary skill in the art at the time of the invention would be motivated to do this in order to reduce the film resistivity of the nanowire (see FIG. 1 of *Deng*).

Claims 133 and 134 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hareland.

Regarding claim 133, *Harland*, discloses all of the limitations of claims 126 but does not disclose whether the nanoscale wire 106 is a single crystal silicon or polycrystalline silicon.

However, as the nanoscale wire is the channel of a transistor it would have been obvious to one of ordinary skill in the art at the time of the invention to form the nanowire out of single crystal silicon. One of ordinary skill in the art would recognize that this would enable/improve the functioning of the transistor formed from the nanowire.

Regarding claim 134, *Harland*, discloses all of the limitations of claims 126 but does not disclose that the mask comprises photoresist.

Harland however does disclose, in column 5, lines 42-48, that the mask 108 comprises any sacrificial material (called a sacrificial gate electrode 119) that is removable or etchable.

As one of ordinary skill in the art would recognize that photoresist is both removable and etchable, and commonly forms sacrificial structures, it would have been obvious to one of ordinary skill in the art to use a mask 108 containing photoresist in the invention of Harland. The claim would have been obvious because the simple

substitution of one known material for another known, equivalent material would have yielded predictable results to one of ordinary skill in the art at the time of the invention.

Claim 139 is rejected under 35 U.S.C. 102(e) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over *Hareland* as evidenced by Wu et al. ("Single-crystal metallic nanowires and ...") (*Wu* hereinafter)

Regarding claim 139, *Hareland* discloses all of the limitations of claims 126 and but does not disclose that the first region is able to carry a current density of at least about 10^8 A/cm^2.

Wu discloses that similarly created nickel silicide nanowires of comparable dimensions can handle approximately $3x10^8$ A/cm^2. Though the current density is limited by the failure of the structure, which will vary based on the exact details of layout and fabrication, it is probably inherent that the maximum current density will be at least about 10^8 A/cm^2 above as evidenced by *Wu*.

However, even if it is not inherent, the claim would still be prima facie obvious as increasing the maximum current density of a device allows it to handle larger currents without being destroyed, and it has been held that discovering an optimum value of a result effective variable involves only routine skill in the art. In re Boesch, 617 F.2d 272, 205 USPQ 215 (CCPA 1980).

Conclusion

The art made of record and not relied upon is considered pertinent to applicant's disclosure.

Chen et al. (US 6,998,333) discloses the creation of single crystal silicon nanowires for use as transistors.

Zhang et al. ("Electrical robust ultralong ...") discloses the maximum current densities for comparably made polycrystalline nickel silicide nanowires.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to DAREN WOLVERTON whose telephone number is (571) 270-5784. The examiner can normally be reached on Monday to Thursday from 9:30 a.m. to 3:00 p.m., EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Matthew Landau can be reached on (571) 272-1731. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/D. W./
Examiner, Art Unit 2813

/Matthew C. Landau/
Supervisory Patent Examiner, Art Unit 2813

DW